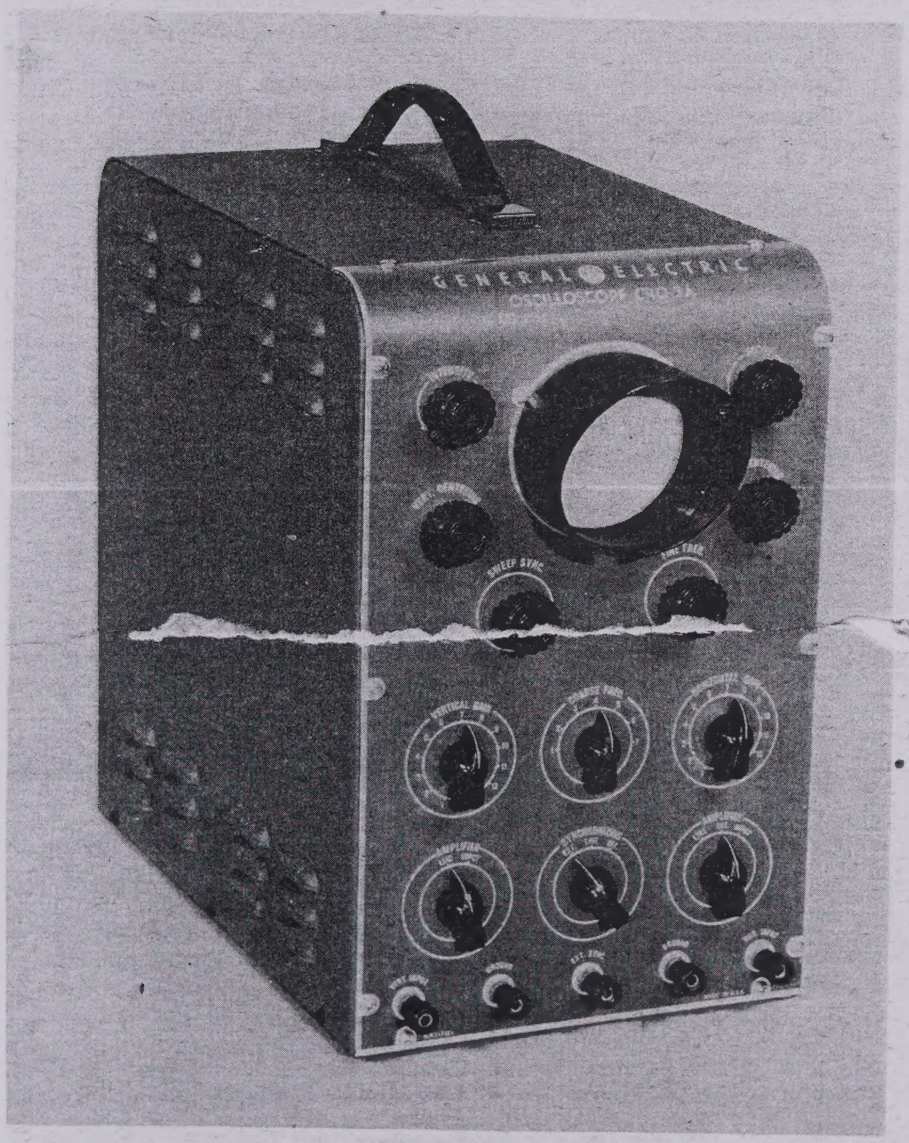
OPERATING INSTRUCTIONS
FOR
CATHODE RAY OSCILLOSCOPE
TYPE CRO-3A

GENERAL ELECTRIC

Electronics Department Specialty Division

Syracuse, N. Y.


GENERAL ELECTRIC
SWEEP SYNC
TIME TRACK

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ELECTRICAL SPECIFICATIONS

VERTICAL AMPLIFIER

Frequency Response (Max. gain only)	20 to 100,000 sinusoidal cycles ± 10%
Sensitivity	.3 volts rms per inch
Square Wave Response (Max. gain only)	20 to 7000 cycles, less than 5° phase shift at 20 cycles
Square Wave Response Any gain setting	20 to 1000 cycles, less than 5° phase shift at 20 cycles
Amplifier Linearity	Less than 10% non-linearity at 1½ times tube diameter deflection
Input Impedance	1 megohm shunted by 45 mmf.
Maximum Input Potential	500 volts rms.

HORIZONTAL AMPLIFIER

Frequency Response (Max. gain only)	20 to 70,000 sinusoidal cycles ± 10%
Sensitivity	.3 volts rms per inch
Amplifier Linearity	Less than 10% non-linearity at 1½ times tube diameter deflection
Input Impedance	1 megohm shunted by 50 mmf.
Maximum Input Potential	500 volts rms.

SWEEP CIRCUIT

Frequency Range	20 to 30,000 cycles in 7 steps
Frequency Vernier	Continuously variable
Retrace	Blanked

SYNCHRONIZATION

External	Binding post
Line	Internal 60 cycle from filament
Internal	From vertical amplifier plate circuit

TUBES

1	3AP1	Cathode Ray
2	6AC7	Amplifiers
1	884	Sweep
2	5Y3GT/G	Rectifiers

POWER SUPPLY

Input Potential	105/120 volts
Input Frequency	50-60 cycles
Power Input	55 watts
Fuse Protection	1 amp. fuse

OPERATING INSTRUCTIONS
FOR
CATHODE RAY OSCILLOSCOPE
TYPE CRO-3A

General Electric Oscilloscope Type CRO-3A has been designed to make measurements and tests in the analysis of electrical circuits, the proper alignment of high-fidelity equipment, the study of changes which can be converted by an appropriate detector into electrical impulses, and in many other applications. Familiarity with the instrument and its capabilities will enable the operator to make other uses of the oscilloscope.

OPERATION
Controls

All controls on this oscilloscope are grouped on the front panel, with labels to identify the functions of each control. The beam controls are all located on the upper portion of the panel, the sweep circuit controls are grouped in the center, and the amplifier controls are at the bottom of the panel. Controls associated with vertical deflection are located on the left side of the panel, and those associated with horizontal deflection are on the right side.

The power switch is combined with the INTENSITY control, located on the upper left corner of the panel. Power input to the oscilloscope is controlled by this switch. To turn the oscilloscope off, rotate the knob on the INTENSITY control in a counterclockwise direction to the OFF position. Rotating the knob clockwise turns the oscilloscope on, and increases the intensity of the beam or spot. Good oscilloscope practice calls for using as low an intensity as is conveniently possible. This prevents burning the screen, and lengthens tube life. Care must be taken not to allow a bright spot to remain stationary on the screen, as a discoloration of the screen will result.

The FOCUS control in the upper right corner of the panel controls the voltage to the focusing anode of the cathode ray tube. By varying this voltage, the electron beam is focused to a point on the screen of the cathode ray tube, thus giving a fine trace.

The centering controls located below the INTENSITY and FOCUS controls are used to center the trace on the screen. VERT. CENTERING moves the trace up and down, and HOR. CENTERING moves the trace from left to right.

FINE FREQ. and COARSE FREQ. controls vary the frequency of the sweep circuit. The COARSE FREQ. control setting determines on what range the FINE FREQ. control will operate. Sweep frequency may be varied between 20 cycles and 30,000 cycles per second in seven steps by the COARSE FREQ. control.

The FINE FREQ. control selects the exact sweep frequency necessary to stabilize the pattern on the screen after the COARSE FREQ. control has selected the proper range of sweep frequencies.

The SWEEP SYNC. controls the amplitude of the synchronization voltage applied on the grid of the 884 sweep tube. The pattern on the screen should be stabilized with as little synchronization voltage as possible in order that the linearity of the sweep will not be disturbed. Use just enough sync voltage to keep the pattern from drifting or jittering.

The gain of the vertical amplifier may be varied at will by means of the VERTICAL GAIN control, which controls the signal voltage applied to the vertical amplifier.

The gain of the horizontal amplifier may be varied at will by means of the HORIZONTAL GAIN control, which controls the voltage applied to the horizontal amplifier input.

Input to the vertical amplifier may be obtained from two sources. This input is selected by the AMPLIFIER control, which has two settings (located on lower left corner of the panel) marked LINE and INPUT. When set on INPUT, the input to the vertical amplifier is connected to the binding post at

the bottom of the panel marked VERT. INPUT, and voltages to be observed are applied to the oscilloscope between that binding post and the post marked GROUND. When this switch is set on LINE, the input of the vertical amplifier is connected internally to a source of voltage at line frequency.

Input to the horizontal amplifier may be obtained from three sources. This input is selected by the control marked AMPLIFIER, which has three settings —LINE, INT. and INPUT. (Located in lower left corner of the panel.) When set on LINE, the input to the horizontal amplifier is connected internally to a source of sine wave voltage at line frequency. This is especially useful when the line frequency is being used as a standard or in tracing hum or ripple voltages. When the switch is set on INT., the input of the horizontal amplifier is connected to the internal linear sweep circuit which produces a sawtooth voltage. When set on INPUT, the input of the amplifier is connected to the binding post on the bottom edge of the panel marked HOR. INPUT.

The SYNCHRONIZING control selects the source of the synchronous voltage to be applied to the internal sweep. The switch has three settings marked EXT., LINE and INT. When set on EXT., the sweep circuit synchronizing voltage is obtained through the EXT. SYNC. binding post. When set on LINE, the sweep circuit input is connected to one half of the filament transformer and is 60 cycle or line frequency. The sweep can be locked to that frequency or to a multiple of it.

The SYNCHRONIZING control is used only when the horizontal AMPLIFIER switch is set to INT. and has no effect on other settings of the horizontal AMPLIFIER switch.

Preparing the Oscilloscope for Use

Although the 3AP1 tube provides a sufficiently brilliant trace for observation of most wave forms under ordinary light conditions, it is preferable that direct light does not strike the screen of the tube. The light will not damage the screen, but the increased intensity of beam required will shorten the life of the screen.

Rotate the INTENSITY control from the OFF position (at the extreme left) about a half turn, and allow a minute for the cathode of the tube to heat. Rotate the FOCUS control about a half turn from the extreme left position and adjust the image on the screen to a thin line or dot. Reduce the intensity of the image until it is just easily visible. If a bright spot of light is permitted to remain on the screen for a long period of time, the screen will be burned and the ability of the screen to reproduce light at that spot will be destroyed.

Rotate the vertical AMPLIFIER switch to the LINE position. This will connect a source of 60 cycle voltage through the vertical amplifier to the vertical plates of the cathode ray tube. Rotate the horizontal AMPLIFIER switch to INT, as it is to be used with the internal linear sweep circuit.

Set the COARSE FREQ. control to give a sweep of approximately 60 cycles (position 2), and vary the FINE FREQ. switch until a single cycle appears on the screen. Advance the SWEEP SYNC. knob just enough to keep the image from drifting. Too much sync voltage will cause the image to distort.

Adjust the VERTICAL GAIN and HORIZONTAL GAIN knobs to bring the image wholly within the boundaries of the screen to a well-proportioned image such as illustrated in Fig. 1A. It is advisable to use shielded leads with the shields grounded in most applications of the CRO-3A Oscilloscope.

If the COARSE FREQ. setting is reduced to position 1 and the FINE FREQ. knob slowly adjusted in the same way, the patterns of Fig. 1B and 1C will be seen, permitting observation of two cycles and three cycles of the voltage being fed to the vertical amplifier because the sweep rates are respectively one half and one third of the frequency being tested.

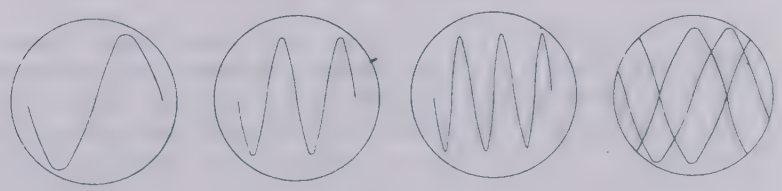


Fig. 1

Misadjustment of the sweep rate to one higher than the frequency of the wave under test will result in multiple traces as shown in Fig. 1D when the sweep rate is one and one half times the frequency of the applied voltage. The remedy is to reduce the sweep rate by turning the FINE FREQ. knob counterclockwise to reduce the sweep rate to a true synchronous value. Similar patterns are caused when the sweep rate is $\frac{2}{3}$, $\frac{3}{4}$, $\frac{4}{5}$, etc., of the frequency of the tested wave.

Application of External Voltage to Horizontal Plates

Some applications of the CRO-3A Oscilloscope will call for application of a voltage other than that of either the 60 cycle line or the internal sweep to the horizontal plates. This is accomplished by rotating the horizontal AMPLIFIER knob to the INPUT position and connecting the voltage between the binding post labelled HOR. INPUT and the GROUND binding post.

Square Wave Testing of Amplifiers

Observing the output of an amplifier when a square wave is applied to the input provides a simple, quick method of determining its transmission characteristics. From such observation, the frequency and phase characteristics of the amplifier may be determined.

In most cases, square waves of two frequencies will suffice to determine the complete performance of the amplifier under test. One frequency should be high enough to eliminate the low-frequency effects and the other should be low enough to include them. In this way, the results can be analyzed separately.

In general, the steepness of the wavefront is an indication of the high-frequency response, and the shape at the top of the rise is a measure of the damping of the circuit. A highly damped circuit will reach its maximum height without any overshoot. An undamped wave will produce a train of oscillations after the initial rise. Excessive damping is indicated by rounding of the wave at the top of the rise. Rounding of the other two corners indicates that the damping decreases from the normal at high frequencies.

By lowering the frequency of the square wave, the low-frequency response of the circuit may be studied. The high-frequency effects, rise time, overshoot and rounding of the corners must be neglected if they are present to a noticeable degree, and only the average shape at the top of the wave should be considered. The low-frequency effects most often encountered are those due to the inability of the coupling capacitor between stages to hold its charge during the flat portions of the cycle, thus causing the top of the wave to slant downward.

Fig. 2 shows output waves from various circuits. "A" represents the applied wave and the wave obtained from a circuit with constant gain at all frequencies. It is highly damped and has constant delay. "B" indicates poor low-frequency response with a delay below normal at low frequencies. In "C", the vertical sides indicate good high-frequency response and the rounded corners excessive damping. In "D", the sloping sides indicate the attenuation of the higher frequencies, high damping and constant delay. "E" indicates either low attenuation or excess gain at high frequencies and underdampings to test the amplifiers connected as follows.

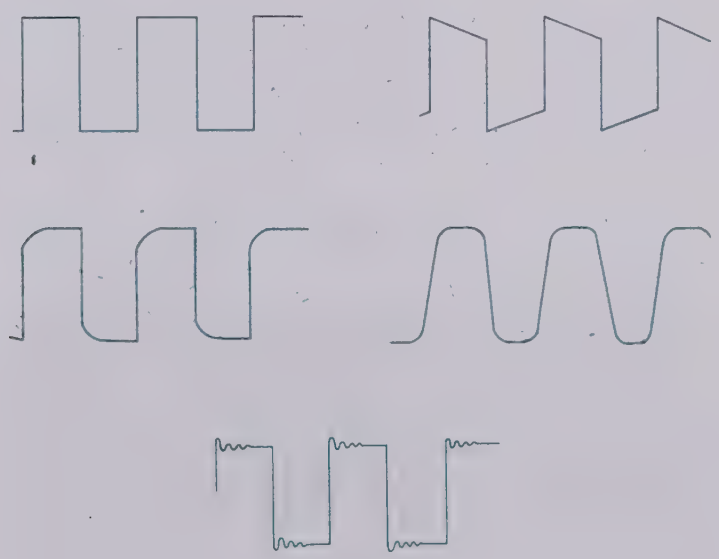


Fig. 2

The CRO-3A Oscilloscope, amplifier and square wave generator are connected as shown in Fig. 3. Prepare the CRO-3A as follows: Rotate the vertical AMPLIFIER knob to INPUT, the SYNCHRONIZING knob to INT. and the horizontal AMPLIFIER knob to INT. The sweep frequency controls are set to obtain a pattern of two or three cycles of the square wave. By comparing the pattern on the screen with the waves shown in Fig. 2, a good idea of the amplifier response may be obtained.

Frequencies between 20 and 100 cycles should be used on this test due to the limitations of the vertical amplifier's square wave response at various gain settings.

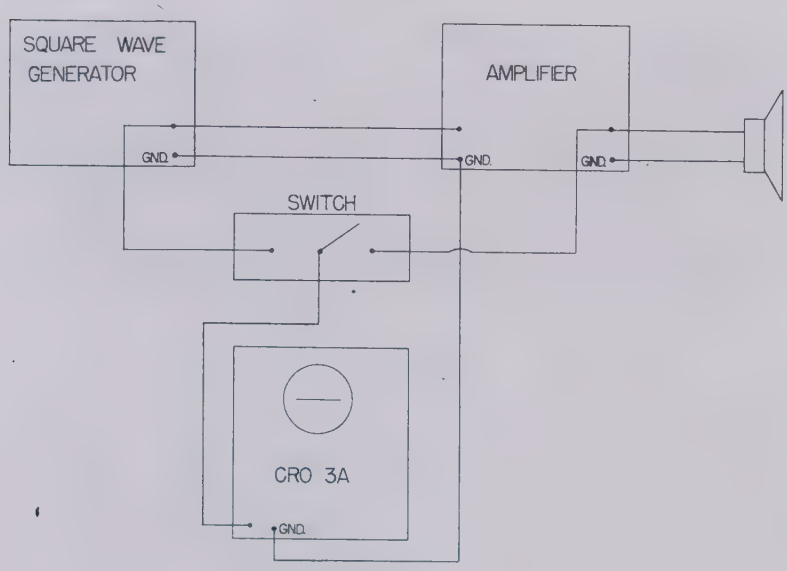


Fig. 3

Phase Shift

Phase shift can readily be determined by this oscilloscope. Using a shielded lead, connect the horizontal INPUT to the input of the amplifier under test. Connect the CRO-3A GROUND connection to the amplifier chassis. Connect another shielded lead with a test prod to the vertical INPUT. Both AMPLIFIER switches should be set on INPUT. Moving the test prod from stage to stage in the amplifier will cause one of the patterns shown in Fig. 4. Internal sweep is not used in this test.

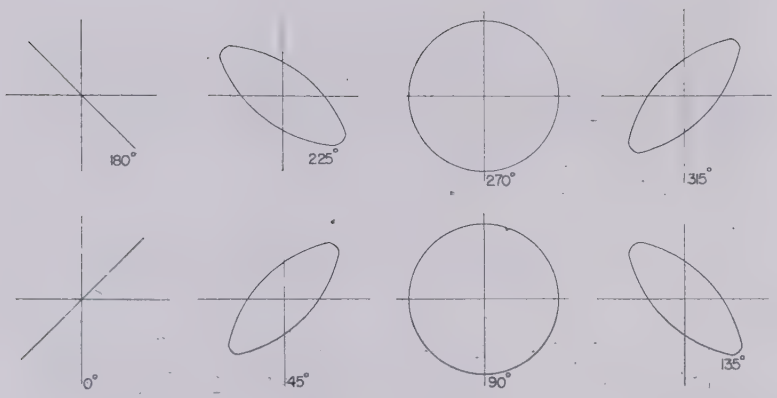


Fig. 4

Lissajou's Figures

Two sine waves of different frequencies which are multiples of each other will form closed figures or Lissajou's figures, depending on the ratio between the two voltages. If one of the frequencies is known, the other can be determined by counting the number of loops formed. Examples of simple figures are shown in Fig. 5. All the above patterns are 1 to 1 ratio.

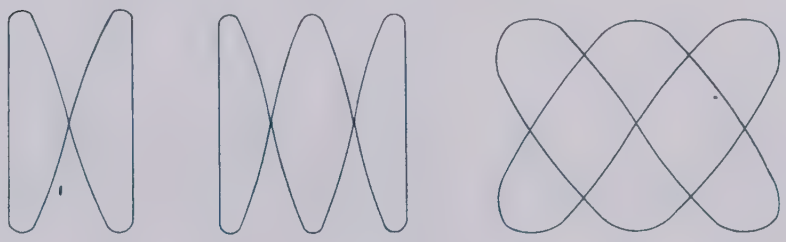


Fig. 5

Tracing Source of Hum in Receiver or Amplifier

Set the horizontal AMPLIFIER to INT., the SYNCHRONIZING knob to LINE, and the vertical AMPLIFIER knob to INPUT. Connect the vertical GROUND binding post to the receiver or amplifier ground point. Set COARSE FREQ. to position 2, and FINE FREQ. knob so it gives a single cycle on the screen when the test lead attached to the VERT. INPUT binding post is touched to the hot side of the filament lines. Move the test probe along the circuit from the second detector to the output, and note the

wave shape at each connection. Hum picked up by the wiring will show a single cycle, because it is 60 cycles (the same as the sweep circuit timing). If the hum is coming through the filter system, two cycles may appear on the screen, indicating the hum is 120 cycles.

If the rectifier is a half-wave type, the hum component is 60 cycle. If it is of the full-wave type, it will be twice that frequency, or 120 cycles.

The test lead used in this test should be a shielded lead, and the test probe should be made of a good insulating material. An unshielded lead would pick up stray AC voltage which would affect the pattern and lead to incorrect interpretation of the hum conditions. Fig. 6 shows one manner of making a shielded test lead for use with the CRO-3A Oscilloscope.

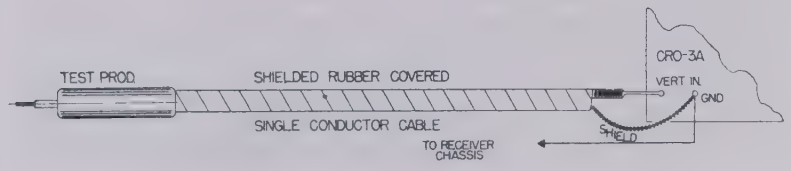


Fig. 6

Voltage frequency may be identified in another manner by switching the horizontal AMPLIFIER to LINE. In this case, the 60 cycle hum will appear as a distorted circle, and 120 cycle hum will be seen as a distorted figure eight.

TROUBLE SHOOTING

Trouble in the CRO-3A may usually be cleared by making a few simple tests.

If horizontal deflection is secured when using the horizontal INPUT or LINE, but no deflection is present on INT., trouble is indicated in the 884 linear sweep circuit. If no horizontal deflection is present, look for trouble in the 6AC7 horizontal amplifier circuit.

Absence of vertical deflection indicates trouble in the 6AC7 vertical amplifier circuit.

Both the vertical and horizontal amplifiers are conventional circuits, with the exception of the inductance in the plate circuit of each amplifier. These inductances L2, L3 are tuned peaking coils, and one is placed in the plate circuit of each amplifier to improve the high-frequency response. These coils have been adjusted at the factory for maximum response and the adjustment should not be changed by anyone unfamiliar with the operation and function of these coils, or by anyone who does not have the necessary equipment.

Be careful when working on this oscilloscope while it is out of the case not to damage the 3AP1 cathode ray tube. If the power is turned on while working on the scope, use extreme care to avoid high voltage which exists in some of the circuits.

REPLACEMENT PARTS LIST

Symbol	Stock No.	Description
	SDM 001	Screen
	SDK 032	Knob (Rd)
	SDK 029	Knob (Bar)
	SJS 028	Socket (Octal)
	SJS 021	Socket (Octal)
T1	STP 008	Transformer (Power)
L2, L3	SLP 001	Perm. Tuned Coil
L1	SLF 005	Choke Filter
	SJS 030	Socket (7 pin)
S4	SSO 004	Rotary Switch
S2	SSO 005	Rotary Switch
S5	SSO 006	Rotary Switch
S3	SSW 017	Wafer Switch
R5A, B, C	URF 1094	Resistor, carbon, 75,000 ohms, 2 watt
R1, R7	URF 073	Resistor, carbon, 10,000 ohms, 2 watt
R4	URE 1108	Resistor, carbon, 300,000 ohms, 1 watt
R6	URE 069	Resistor, carbon, 6800 ohms, 1 watt
R8	URE 097	Resistor, carbon, 100,000 ohms, 1 watt
R15, R17	URE 1091	Resistor, carbon, 56,000 ohms, 1 watt
R23	URE 1051	Resistor, carbon, 1200 ohms, 1 watt
R11, R12	URD 129	Resistor, carbon, 2.2 megohm, ½ watt
R13, R19	URD 121	Resistor, carbon, 1 megohm, ½ watt
R25	URD 123	Resistor, carbon, 1.2 megohm, ½ watt
R14	URD 107	Resistor, carbon, 270,000 ohms, ½ watt
R16, R20	URD 1036	Resistor, carbon, 300 ohms, ½ watt
R22	URD 073	Resistor, carbon, 10,000 ohms, ½ watt
R27	URD 083	Resistor, carbon, 27,000 ohms, ½ watt
R28	URD 105	Resistor, carbon, 220,000 ohms, ½ watt
C3, C4, C12	SCX 001	Capacitor, electrolytic and mounting plate
C8	UCU 1020	Capacitor, mica
C17	UCU 1028	Capacitor, mica

C18	UCU 1044	Capacitor, mica
C11	UCU 1052	Capacitor, mica
C13, C14	UCU 005	Capacitor, mica
C2, C15, C16	UCC 045	Capacitor, paper
C5, C6	UCC 051	Capacitor, paper
C19	UCU 1036	Capacitor, mica
C20	UCC 040	Capacitor, paper
C9, C10, C22	UCC 048	Capacitor, paper
C21	UCC 042	Capacitor, paper
C7	SCC 022	Capacitor, paper
C1	SCC 021	Capacitor, paper
R21	SRC 026	Potentiometer
R18	SRC 027	Potentiometer
R9, R10	SRC 028	Potentiometer
R3, R24, R26	SRC 029	Potentiometer
R2	SRC 030	Potentiometer
C23	SCC 020	Capacitor, paper
	SEF 004	Fuse
	SMM 019	Visor (Scope Tube)

SOCKET VOLTAGES

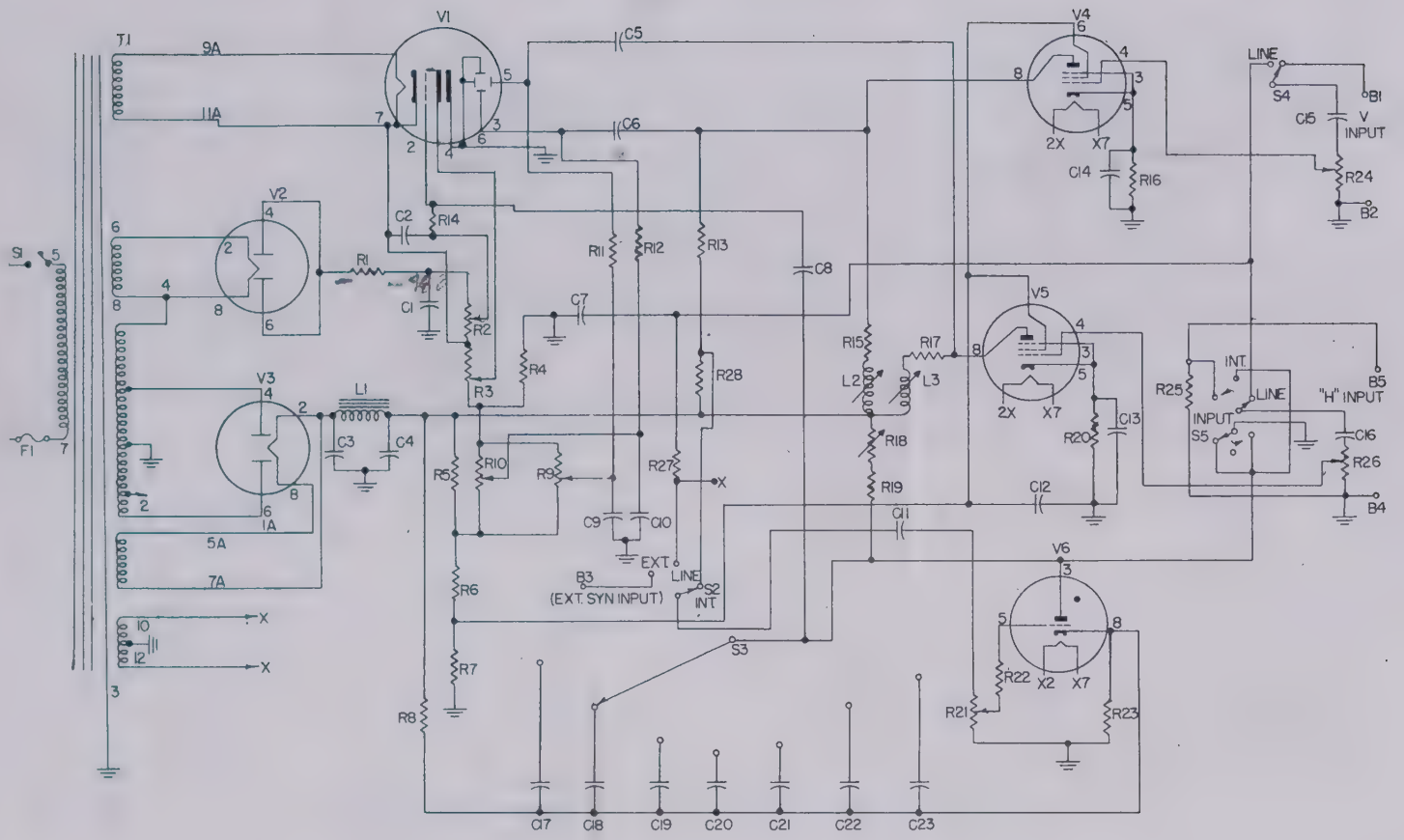
DC Voltages

All measurements made with 20,000 ohms/volts instrument from pin indicated to ground.

Tube	Pin No.							
No.	1	2	3	4	5	6	7	8
V-1	-915	-915	-130	-915	-130	0	-915	–
V-2	–	755 AC	–	-980	–	-980	–	755 AC
V-3	–	425	–	375	–	375	–	425
V-4	–	–	1.4	3.2	1.4	77	–	225
V-5	–	–	1.2	3.6	1.2	77	–	250
V-6	–	–	26	–	0.1	–	–	4.4

Filament Voltages

Tube No.	Pins	Voltage (a-c)
V-1	1 - 7	2.5 volts
V-2	2 - 8	5.0 volts
V-3	2 - 8	5.0 volts
V-4	2 - 7	6.3 volts
V-5	2 - 7	6.3 volts
V-6	2 - 7	6.3 volts


T1
9A
11A
5A
7A
1A
S1
F1
V1
V2
V3
V4
V5
V6
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
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C16
C17
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R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
R23
R24
R25
R26
R27
R28
L1
L2
L3
S2
S3
S4
S5
B1
B2
B3
B4
B5
LINE
INT
EXT.
(EXT. SYN INPUT)
V INPUT
"H" INPUT
INPUT
2X
X7
X2
X

USER WARRANTY

General Electric Company warrants to the purchaser of the new General Electric Oscilloscope Type CRO-3A that any part thereof (except electronic tubes incorporated therein which are covered by the Company's standard tube warranties) which proves to be defective in material or workmanship within one (1) year from the date of original purchase for use will be repaired or replaced. Any defect in said Oscilloscope Type CRO-3A should be brought to the attention of the General Electric dealer from whom it was purchased, who shall be authorized to furnish or arrange for repairs or replacements within the terms of this warranty.

The foregoing is in lieu of other warranties, express or implied, and General Electric Company neither assumes, nor authorizes any person to assume for it, any other obligation or liability in connection with said Oscilloscope Type CRO-3A.

MP MASTER
MA32624